CONDUCTIVE LID AND METHOD OF EMPLOYING A CONDUCTIVE LID IN AN INTEGRATED CIRCUIT

FIELD OF THE INVENTION

[0001] The present invention relates generally to a conductive lid functioning as a heat sink for an integrated circuit, and in particular, to a method of employing a conductive lid with an integrated circuit.

BACKGROUND OF THE INVENTION

[0002] Heat sinks are used in a variety of electronic devices to dissipate heat from the device, preventing any failure of or damage to the device. Heat sinks are made of a variety of heat conducting materials and are formed in a variety of shapes to adequately conduct the heat from the device. More specifically, heat sinks are also used with integrated circuits to reduce the heat of the semiconductor die to enable the integrated circuit to function properly. The purpose of the heat sink is to keep a semiconductor junction, such as a junction of the transistor, below a maximum specified operating temperature. Knowing the power that will be dissipated in a given integrated circuit, it is possible to calculate a junction temperature. Because the transistor life declines rapidly at operating temperatures near a maximum operating temperature, the heat sink is chosen to keep the semiconductor junction below the maximum specified temperature.

[0003] All semiconductor packages can use other thermal enhancements, which can range from simple airflow to schemes that can include passive as well as active heat sinks. This is particularly true for the high performance flip chip packages which can be designed to handle in excess of 20 watts with arrangements that take system physical constraints into consideration. The use of lightweight finned external passive heat sinks can be effective for

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dissipating up to 10 watts in the bigger packages. For moderate power dissipation (e.g. less than 6 watts), the use of passive heat sinks and heat spreaders attached with thermally conductive double-sided tapes or retainers can offer quick thermal solutions in these packages.

[0004] Typically, flip chip packages are thermally enhanced BGAs with die facing down. They are offered with exposed metal heat sink at the top. These are considered high-end thermal packages and they lend themselves to the application of external heat sinks (passive or active) for further heat removal efficiency. However, these types of conductive lid heat sinks, often exhibits the problem of separating from the top of a package. Because the adhesion strength of the adhesive is sometimes not strong enough to hold the conductive lid to the package, the conductive lid can come off of the package.

[0005] Accordingly, there is a need for an improved conductive lid functioning as a heat sink and method of employing a conductive lid with an integrated circuit.

SUMMARY OF THE INVENTION

[0006] The embodiments of the present invention relate to adding through-holes to the corners and/or sides of a conductive lid for an integrated circuit. The holes may be made anywhere along the epoxy dispense area to improve the strength of the bond between the conductive lid and the substrate. The configuration and total number of holes created can vary for each application. The holes preferably extend from the bottom of the conductive lid which is bonded to the package through to the top of the conductive lid. Although straight holes can also be utilized, the holes can be tapered in shape with the top larger in diameter.

[0007] In particular, a conductive lid adapted to function as a heat sink for an integrated circuit comprises a recessed portion adapted to receive a die of an integrated circuit and a foot portion having a flat surface adapted to

be coupled to a substrate of the integrated circuit. A through-hole or plurality of through-holes are located in the foot portion. The through-hole is adapted to receive an adhesive to secure the conductive lid to the substrate of the integrated circuit. The through-hole could be a straight through-hole, or could be a tapered through-hole, such a conical through-hole or a multi-diameter through-hole or other through-hole where the hole has a plurality of widths. The adhesive is preferably a thermally conductive resin to conduct heat from the integrated circuit.

[0008] A method of forming a conductive lid for an integrated circuit is also disclosed. The method generally comprises the steps of forming a recessed portion for receiving a die of an integrated circuit; creating a foot portion around the recessed portion; and providing a plurality of through-holes in the foot portion. The method could be implemented by using a molding process, such as injection molding, or by a stamping process, wherein the through-holes are either punched or drilled in the foot portion of the conductive lid. Methods of securing a conductive lid to a substrate by receiving an adhesive in a through-hole, and using a conductive lid having a through-hole to conduct heat from an integrated circuit are also disclosed.

BRIEF DESCRIPTION OF THE DRAWINGS

[0009] Fig. 1 is a top plan view of an integrated circuit having a conductive lid according to the present invention;

[0010] Fig. 2 is a cross-sectional view of the integrated circuit having a conductive lid of Fig. 1 according to one embodiment of the present invention;

[0011] Fig. 3 is a cross-sectional view of the integrated circuit having a conductive lid of Fig. 1 according to an alternate embodiment of the present invention.

[0012] Fig. 4 is a cross-sectional view of the integrated circuit having a conductive lid of Fig. 1 according to a further embodiment of the present invention;

[0013] Fig. 5 is a more detailed cross-sectional view of a packaged integrated circuit having a conductive lid of Fig. 1 according to one embodiment of the present invention;

[0014] Fig. 6 is a flow chart showing a method of forming a conductive lid by a molding process according to an embodiment of the present invention;

[0015] Fig. 7 is a flow chart showing a method of forming a conductive lid by a stamping process according to an embodiment of the present invention;

[0016] Fig. 8 is a flow chart showing a method of securing a conductive lid in an packaged integrated circuit according to an embodiment of the present invention; and

[0017] Fig. 9 is a flow chart showing a method of using a conductive lid on an integrated circuit according to an embodiment of the present invention.

DETAILED DESCRIPTION OF THE DRAWINGS

[0018] Turning first to Fig. 1, a top plan view of an integrated circuit having a conductive lid according to the present invention is shown. In particular, a conductive lid functioning as a heat sink for a integrated circuit comprises a through-hole 104. A plurality of through-holes 104 could be added to the corners and/or sides of the conductive lid. The configuration and total number of holes created can vary for each application. The through-holes may be made anywhere along the epoxy dispense area to improve the strength of the bond between the conductive lid and the substrate. The through-holes of Fig. 1 are positioned on both the corners and along the sides, and are generally evenly spaced. As shown in the cross-sectional view of Fig. 2 taken at lines A-A of Fig. 1, an integrated circuit 200 comprises through-holes 104 extending from the top 206 of the conductive lid to the bottom of the

conductive lid at a foot portion 208, which preferably extends around the periphery of the conductive lid. The conductive lid 102 is positioned on the package 204. The conductive lid could be made of any conductive material, such as copper or aluminum, or any other suitable metal or alloy. During lid attachment, the epoxy will penetrate into the through-holes and become cured. When the integrated circuit is packaged is assembled, as will be described in more detail in reference to Fig. 5, the lid would then be "anchored" in place by the epoxy.

[0019] Turning now to Fig. 3, a cross-sectional view of the integrated circuit having a conductive lid according to an alternate embodiment of the present invention is shown. While straight holes can be utilized as shown in Fig.1, the holes can be tapered in shape with the top generally larger in diameter to improve the adhesive affect of the through-hole. In particular, a conducted lid 302 comprises a through-hole 304 which is adjacent to a recess 306. The through-hole 304 preferably extends from the top 308 of the conductive lid to a foot portion 310. The through-hole could be formed by an injection molding, drilling or some other suitable method of forming holes in a heat sink. Although a conical shaped hole is shown, any other shape could be employed. The larger diameter at the top acts like the head of a screw or nail to prevent separation of the metal lid from the package.

[0020] Turning now to Fig. 4, a cross-sectional view of the integrated circuit having a conductive lid according to a further embodiment of the present invention is shown. According to the embodiment of Fig. 4, a conductive lid 402 comprises an example of a multi-diameter hole 404 having a small hole 406 formed from a foot portion 408 and a large hole 410 formed from the top 412 of the conductive lid. Small hole 406 and large hole 410 generally form cylindrical portions. The larger diameter hole at the top also acts

metal lid from the package when the adhesive material extends into the larger hole 410.

[0021] Turning now to Fig. 5, a more detailed side elevation of a packaged integrated circuit having a conductive lid according to one embodiment of the present invention is shown. In particular, a semiconductor die 502 having a plurality of bumps 504 of a flip chip device is coupled to a substrate 506. Underfill 508 and a thermal grease 510, which is thermally conductive, surround the semiconductor die, as is well known in the art. The substrate may further comprise a plurality of contacts 520. A recess 512 of the conductive lid provides room for the semiconductor die 502 and defines a foot portion 514. As can be seen in Fig. 5, the foot portion is positioned on an adhesive material 516. The adhesive material could be any type of epoxy or resin used for attaching a heat sink to a substrate. The adhesive material is also preferably thermally conductive for better heat dissipation. An example of an appropriate adhesive material is a Modified Cyclo-Olefin Thermoset (MCOT) supplied by Ablestik Laboratories, Rancho Dominguez, California. As can be seen, a portion of the resin 518 extends into the through-hole 304 to adhesive material 516 to secure the conductive lid 302 to the substrate 506.

[0022] Turning now to Fig. 6, a flow chart shows a method of forming a conductive lid by a molding process according to an embodiment of the present invention. In particular, a mold for an injection molding process to create a conductive lid for integrated circuit is formed at a step 602. A recessed portion is formed for receiving a die of an integrated circuit using the mold at a step 604. A foot portion around the recessed portion is formed using the mold at a step 606. Finally, a plurality through-holes are formed in the foot portion using the mold at a step 608. The mold could comprise any type of mold for any appropriate molding process, such as injection molding. The resulting

conductive lid could be any type of conductive lid having a through-hole for receiving an adhesive material, such as the conductive lids shown for example in Figs. 2-4.

[0023] Turning now to Fig. 7, a flow chart shows a method of forming a conductive lid by a stamping process according to an embodiment of the present invention. In particular, a conductive lid for an integrated circuit is created at a step 702. A recessed portion in the conductive lid for receiving a die of the integrated circuit is formed a step 704. A foot portion is formed around the recessed portion of the connective lid at a step 706. A plurality of through-holes are formed in the foot portion in a first step at a step 708, and the plurality of through-holes are formed in a second step at a step 710. An example of a conductive lid having through-holes formed by steps 708 and 710 can be seen in cross-sectional view of Fig. 4.

[0024] Turning now to Fig. 8, a flow chart shows a method of securing a conductive lid in a packaged integrated circuit according to an embodiment of the present invention. A conductive lid for an integrated circuit having through-holes is provided at a step 802. An underfill is provided between a substrate and a die of the integrated circuit at a step 804. A thermal grease is also provided on top of the die of the integrated circuit a step 806. An adhesive material is also applied to the substrate at a step 808. Finally, the conductive lid is positioned on the adhesive material such that the adhesive extends into the through-hole at a step 810. The method of Fig. 8 could be used to secure any type of conductive lid having a through-hole, such as a conductive lid shown in Figs. 2-4.

[0025] Finally, turning to Fig. 9, a flow chart shows a method of using a conductive lid on an integrated circuit according to an embodiment of the present invention. A substrate for receiving a die is provided at a step 902. A thermal grease is provided to the die at a step 904. An adhesive material is applied to the substrate at a step 906,

and the conductive lid having a through-hole extending thru the conductive lid to substrate secures the conductive lid to substrate. Finally, heat from the integrated circuit is conducted from the die by way of the conductive lid and the adhesive material in the through-hole at a step 910. The method of Fig. 9 could be used to conduct heat from the die of any integrated circuit having a conductive lid with a through-hole, such as a conductive lid shown in Figs. 2-4.

[0026] It can therefore be appreciated that the new and novel heat sink and method of attaching a heat sink to an integrated circuit has been described. It will be appreciated by those skilled in the art that numerous alternatives and equivalents will be seen to exist which incorporate the disclosed invention. As a result, the invention is not to be limited by the foregoing embodiments, but only by the following claims.